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Research Report

USE OF RESPIRATORS AND METHODS OF DETERMINING FACE FIT

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ABSTRACT

The methods that are used for determining face fit for respiratory protective devices at Sandia Laboratory are described. Individuals are tested, after their threshold for amyl acetate has been determined, in a room containing a known concentration of amyl acetate. The penetration between the mask and the face is determined by using this information. The criteria for mask issue are given with cleaning and maintenance procedures.

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USE OF RESPIRATORS AND METHODS OF DETERMINING FACE FIT

Introduction

Determining proper respirator face fit is a vital link in providing adequate inhalation protection for personnel working in toxic radioactive and chemical atmospheres. Proper face fit of respirators became more important when dealing with the toxic materials found within the nuclear industry. The Bureau of Mines had no approved schedule for testing masks that were to be used for such materials, so tests were made within the nuclear industry which revealed that particular care in mask fitting was necessary. It was shown at many AEC locations that mask leakage could be severe.

The wearing of an improperly fitted Bureau of Mines approved canister and face piece is dangerous because the worker has a false sense of security which might cause him to be more severely exposed to toxic materials than he would have been had he not worn the respirator at all. In recent years, the practicing health physicist and industrial hygienist has been increasingly concerned about this problem in light of the increasing use of extremely toxic materials such as plutonium and beryllium where an overexposure could have grave health effects.

Respirator use at Sandia Laboratory is similar to that in other plants in that we provide the individual with a mask that will give him the utmost of protection and the least discomfort. In addition, at Sandia the need for respiratory and the type best suited for the particular task are determined only by an industrial hygienist or by a health physicist. Personnel who need respirators can obtain them only upon the approval of one of the above persons, and the masks are personally fitted to the individual. The mask fit is then tested in a relatively innocuous atmosphere of amyl acetate to determine penetration between the mask and face.

Fitting of Respiratory Protective Devices

Sandia Laboratory is fortunate as individuals who require these protective devices are usually located close to the building where the devices are fitted. This allows individuals to come to the fitting station with a minimum of lost time.

The individual is requested to report to the respirator fitting station by his supervisor, who normally will have made prior arrangements for the fitting. He is given instruction upon arrival in the best method for applying the mask to his face, whereupon he is asked to apply the mask to his face. A cursory check is made by covering the intake ports and allowing the mask to collapse toward the individual's face by the resulting vacuum. If this check indicates a leak, another mask is tried until the test is successful.

The individual is now ready for a more complete test of the mask utilizing the individual's sense of smell.* To determine one's odor threshold, the individual is requested to sniff a 1-ppm concentration of amyl acetate (Figure 1), which seems to be the threshold for most individuals; however, a large number of individuals can detect 0.1 ppm. Sometimes, a person with a cold or respiratory disorder may have an odor threshold as high as 10 ppm. These concentrations of amyl acetate are available, having been previously prepared in a large carboy as illustrated in Figure 2.

The individual is then placed in the respirator test room (Figure 3), and exposed to concentrations of amyl acetate ranging up to at least 100 times his odor threshold. At this time the mask contains an organic solvent canister that has been previously approved by the Bureau of Mines for the mask and canister combination. This test is performed in a 10.3 cubic meter room. The room contains a 3-foot wide door with an adjustable grille in the lower portion of the door. An exhaust grille is located in the ceiling of the room which is closed and sealed by a small trap door. This room has been tested with a smoke bomb and the leaks that were detected were sealed and room retested. The interior surfaces of the room were painted with two coats of epoxy paint, and the floor has asphalt tile laid on concrete.

The amyl acetate vapor is generated by dropping the liquid upon a large piece of 1-inch aluminum plate that has been machined out in the center to a depth of approximately

*In rare instances, this technique will not work, e.g., persons suffering from anosmia. Our Medical Department reports this occurs in about 1 in 4000 persons.

Figure 1. Odor Detection Test - Amyl Acetate

Figure 2. Test Chamber Containing Amyl Acetate

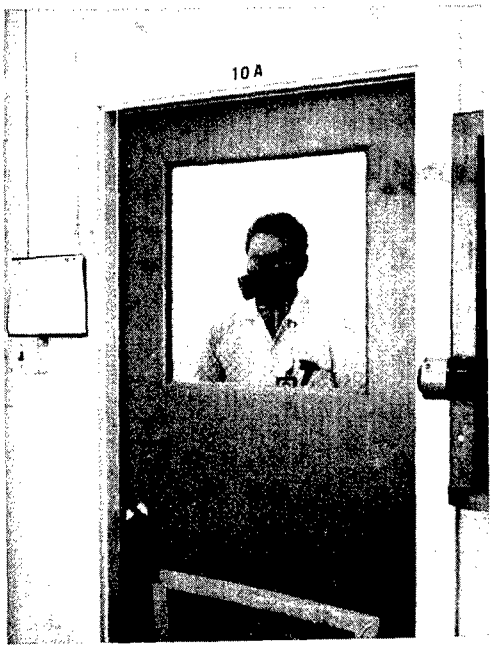

Figure 3. Respirator Testing Room for Face Fit

1/4 inch (Figure 4). The aluminum plate is heated to 300°F. The vapor is distributed uniformly with a fan (Figure 5) and attains a concentration of 600-1000 ppm in 15-30 seconds. The concentration is checked with a calibrated J-W combustible gas indicator (Figure 6). If the individual detects no odor, the mask is issued with the proper canister for the anticipated work. The mask can be fitted to the individual in less than 2 minutes.

To date, approximately 24 individuals have been checked using this method to test the fit. Table I presents results of selected mask fittings. The sequence of fitting the masks is first to try mask A; if the fit is not good, mask B is tried; mask C is tried if necessary. Occasionally, a full-face mask must be issued because a good fit with a half-mask is not obtainable.

From Table I, a < 0.4 percent penetration, as an example where a gas or vapor is involved, means that no more than 4 parts in 1000 would penetrate between the mask and face interface. For exposures to particulates a 0.4 percent penetration allows no more than 40 micrograms/M^3 inside the mask when the atmospheric concentration is 10,000 micrograms/M^3. Thus, the atmospheric concentration for beryllium can remain at 500 micrograms/M^3 for 8 hours and the concentration inside the mask will be at the threshold limit value or less. Canisters that contain high efficiency filters (99.97 percent efficient) give more protection than the seal between the face and the mask.

Criteria for Mask Usage at Sandia

Exhaust ventilation is normally used to avoid the use of respiratory protection. In the event it is not possible to provide exhaust ventilation, then respiratory protection is used to protect the individual. Masks and respirators are issued to an individual depending on the material to which the individual is exposed and on the other factors involved, such as time of exposure and potential concentrations.

If an unknown concentration of a highly toxic material is encountered, a positive pressure supply system is used. If the concentration is known, a half-face mask may be used providing the concentration does not exceed 10 times the acceptable limit, and eye protection is not necessary. If the concentration exceeds the acceptable limit by 10 times, and is not more than 100 times the acceptable limit, a full-face mask may be used for the particular toxic atmosphere. (Based upon Appendix B, Recommendations Regarding Respiratory Protection Against Highly Toxic Aerosols, Respiratory Protective

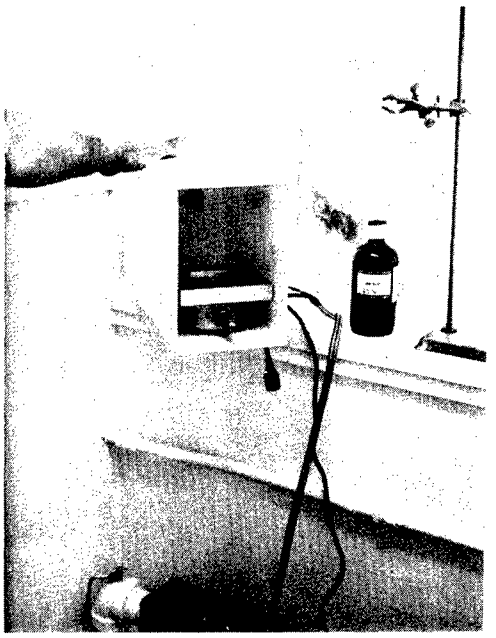

Figure 4. Amyl Acetate Vapor Generator

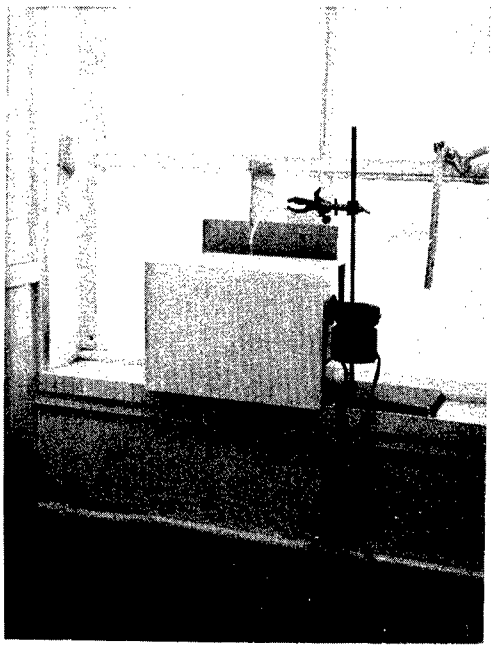

Figure 5. Side View of Generator and Fan

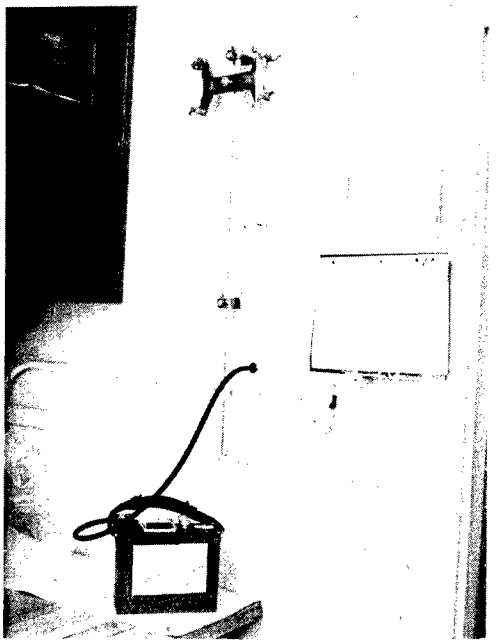

Figure 6. Amyl Acetate Concentration Test

TABLE I

Mask Penetration of Various Half-Face and Full-Face Masks

Test No.	Mask A	Mask B	Mask C	Amyl Acetate Concentration in Test Room (ppm)	Individual's Detection Limit (ppm)	Penetration by Amyl Acetate (%)
			Half-Masks			
1	Negative Fit	Negative Fit	Positive Fit	300	1	<0.4
2	Negative Fit	Positive Fit	No attempt	300	1	<0.4
3	Positive Fit	No attempt	No attempt	300	1	<0.4
4	Negative Fit	Positive Fit	No attempt	300	1	<0.4
5	Negative Fit	No attempt	No attempt	300	1	<0.4
6	No attempt	Positive Fit	No attempt	300	1	<0.4
7	Negative Fit	Positive Fit	No attempt	500	1	<0.2
8	Negative Fit	No attempt	Positive Fit	200	1	<0.5
			Full-face Masks			
1	Positive Fit	No attempt	No attempt	1000	1	<0.1
2	Positive Fit	No attempt	No attempt	1000	1	<0.1

Devices Manual, American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists.)

Paper masks are issued only to those personnel who may be exposed to nuisance dusts such as those generated when shoveling earth, cutting wood, or cleaning a filter which contains atmospheric dusts. They are issued only in the numbers needed for the job to avoid indiscriminate use. The individuals receiving the masks are warned not to allow them to be used for other purposes.

Half-masks are used only in low concentrations of relatively harmless agents. Examples would be cutting of certain metals, painting in a well ventilated area (our paint shop is equipped with a downdraft exhaust system), and mixing ceramic type powders. Again, a representative from the Environmental Health Department analyzes each request and determines the type of respiratory equipment needed.

Full-face masks are used in toxic atmospheres which may contain (1) highly toxic agents, (2) higher concentrations of agents, or (3) in those which require eye protection. Examples are (1) beryllium dusts, (2) concentrations exceeding the acceptable limit by 10 times, but not more than 100 times the acceptable limit, and (3) eye irritants such as ammonia or chlorine.

An air supplied respirator is used in those areas which (1) may not contain sufficient quantities of oxygen, or (2) those in which the concentration of the agent is too high, or (3) if the concentration of a highly toxic agent is unknown. Examples would be spray painting in a closed tank or an entry into a tank or pit. Our standard for self-contained air is the Tentative Standard For Compressed Air For Human Consumption, published by the Compressed Gas Associated, New York.

All air compressions are analyzed by our chemistry laboratory to insure high quality of breathing air. Before compression, the air is passed through an ultrafilter, then through an activated charcoal bank. It is stored in large steel containers pending lab analysis. Upon laboratory approval of purity, it is transferred to the small "back-carry" cylinders for use.

Cleaning Masks and Maintenance

At present, the masks, hoses, and large parts are being cleaned by a commercial laundry. The service has been satisfactory for the few months of use. Only one or two masks have been damaged out of several hundred that have been cleaned. Preliminary check for bacteria indicates a cleaning sufficient to reduce the bacteria colony count to an acceptable level. Tests are made from time to time to evaluate the cleansing of the masks.

Parts for the masks are maintained at the respirator fitting station. The masks are repaired, if necessary, when they are returned from the laundry. Mask fittings are rescheduled periodically depending on the frequency of their use. An individual using a mask daily is required to have a monthly inspection.

Conclusions

The method of testing the face fit for an individual to a respiratory protective device at Sandia Laboratory has been shown to be adequate. The use of a test chamber using amyl acetate has proven satisfactory to check mask penetration.

The penetration of amyl acetate into a mask has been shown to vary from 0.1 to 0.5 percent, depending on the type of the mask. Full-face masks appear to give greater protection.

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